ADMINISTRATIVE NOTE:
NEW REQUIREMENTS/PROCEDURES

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BAA 02-15 PROPOSER INFORMATION PAMPHLET

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The Defense Advanced Research Projects Agency (DARPA) often selects its research efforts through the Broad Agency Announcement (BAA) process. The BAA will be posted directly to FedBizOpps.gov, the single government point-of-entry (GPE) for Federal government procurement opportunities over $25,000. The following information is for those wishing to respond to the Broad Agency Announcement.

MOBILE AUTONOMOUS ROBOT SOFTWARE (MARS) ROBOTIC VISION 2020, SOL BAA 02-15, DUE: 04/03/03; POC: DR. DOUGLAS W. GAGE, DARPA/ITO; FAX: (703) 522-7161

The Defense Advanced Research Projects Agency (DARPA) is soliciting proposals for the design, development, integration, and demonstration of perception-based autonomous robots that effectively operate in real-world environments and interact with humans and with other robots. The key enabling strategy for this effort is the structured incorporation into the system of operator intervention, machine learning, and other techniques so that the system's autonomous capabilities can be iteratively and methodically improved, resulting in the evolutionary development of the revolutionary capabilities needed to support the Joint DARPA/Army's Future Combat Systems (FCS) and other military transformational thrusts.

The software being developed under the Mobile Autonomous Robot Software (MARS) program will create significant, asymmetric, military advantage by enabling the pervasive employment of an entirely new class of unmanned, autonomous military systems. By comparison, many current military systems are manned, with the human on-board the platform to provide all synchronous command and control (for both platform and payload operation). This constraint imposes severe limitations on the acquisition, sustainment, and operational employment of these systems. The few unmanned systems currently employed are remote controlled. This also engenders significant limitations including: degraded system performance by inherently systemic, command and control latencies; limited operator performance by the quantity and quality of "telepresence" that can be provided to the remote operator; unreliable wireless command and control links; and extremely limited suitable spectrum bandwidth. For the few, relatively autonomous systems, the state-of-the-art for software-enabled, autonomous control (such as waypoint flight control) is drastically inferior to the aggressive, human-enabled control exhibited by high-performance manned platforms, especially for aircraft.

This solicitation seeks proposals in the following research areas:

- Structured software modules that will enable human operators to assist the robots through intervention so that the robot fully encounters its operating environment. As the level of robot autonomy increases, the MARS program goal is to double the

average time between required operator interventions and reduce by half the average operator time required per intervention.

- Learning and adaptation tools that impart knowledge through reinforcement, training, or emulation from operator inputs to evolve and improve autonomous perception and behavior.

- Robot self-monitoring and the systematic assessment of perception and behavior performance in terms of quantitative metrics to identify specific research objectives that carry the highest operational payoff in terms of increasing overall system performance.

- Information exchange interfaces supporting interaction between robots and humans in various roles (teammates, bystanders, supervisors, operators, and adversaries).

- Software components that capture an abstracted perception-based representation of a robot's "experience" as it moves through its environment, and that can use this representation to retrace the trajectory to provide retrotraverse, route replay, "go to point X", and other capabilities.

- Sensor-based algorithms to enhance perception capabilities for sensing, interpreting, and "understanding" environmental features and humans.

- Behavior software components and architecture structures to perform robot tasking and actions in the physical world.

MARS Robotic Vision 2020 supports the long-term MARS program concept of providing the foundational robotic system technologies necessary to achieve revolutionary capabilities that enable robotic situational awareness, "common sense," physical manipulation, and interaction, so that robots can serve as trusted team members performing tasks collaboratively alongside humans and remove humans from dangerous environments.

TECHNICAL AREAS

A number of technical capabilities in the areas of interest have been developed under the initial MARS Program BAA 99-09. These efforts are identified at http://www.darpa.mil/ito/research/mars/projlist.html. The purpose of this second MARS BAA is to integrate relevant technologies, including but not limited to those that have been developed under MARS program efforts, into one or more experimental system testbeds in order to (1) demonstrate the effectiveness of learning and adaptation, operator intervention, and other strategies for the evolution of autonomous capabilities, and (2) assess the utility and effectiveness of the individual constituent technologies in supporting these strategies. A presentation describing the "Robotic Vision 2020" evolutionary development strategy is available online at http://www.darpa.mil/ito/research/proceedings/mars01mar/RV2020-010322.ppt.

The following technical areas are of particular interest to this solicitation:

- ***Tools to Exploit Operator Intervention.*** When an unmanned ground vehicle that is navigating autonomously encounters a situation that it can not handle satisfactorily, it must rely on operator intervention to return it to a state from which it can proceed. In current systems, this is often manifested as some sort of emergency stop, followed by a period of teleoperation. The operator reactivates the autonomous control software when appropriate. The result is that the system's sensors and perception software are prevented from actively encountering precisely those portions of the operating environment which provide the greatest challenges to the system. The system software must be structured so that the robot can continue to fully "experience" its operating environment even when the human operator intervenes. Operator intervention may be required at any of a number of different levels, including high level planning, behavior selection, and perception. In each case, the software must provide the operator with the information needed to intervene effectively and efficiently, and present it in an appropriate manner. In some cases, the robot may need to maintain an explicit model of the operator's task loading and performance; in all cases the interface design must reflect the operator's needs and capabilities. Operator intervention should be exploited to support the evolution of system autonomy on at least two levels: (1) by providing input to machine learning techniques to support immediate system adaptation, and (2) by identifying which situations require operator intervention because autonomous capabilities fail, thereby helping to establish priorities for near-term system tailoring and for longer term research initiatives. Finally, measuring the amount of operator intervention required provides a metric for judging the system's "level of autonomy" – the less intervention, the higher the imputed level of autonomy. As the level of robot autonomy increases, the MARS program goal is to double the average time between required operator interventions and reduce by half the average operator time required per intervention.

- ***Machine Learning and Adaptation Tools.*** Efforts pursued under MARS BAA 99-09 have advanced the development of a number of machine learning techniques, and applied them to robotic autonomy in various roles, such as behavior selection, behavior parameter tuning, and perceptual classification. Machine learning efforts under this current BAA should be focused on the quantitative assessment and validation of specific techniques in specific system roles. The development of test bed infrastructure to support the structured comparison of multiple techniques is especially encouraged.

- ***Component Performance Assessment.*** Tools that support the systematic assessment of perception and behavior performance in terms of quantitative metrics are absolutely critical to the success of an "evolution" based approach to the development of autonomy. As mentioned above, the degree of operator intervention required constitutes one measure of system autonomy; other metrics are needed at the subsystem level, in order to identify specific research objectives that carry the highest operational payoff in terms of increasing overall system performance.

- ***Tools for Interaction between Robots and Humans***. Robots must be able to interact with humans in a number of very different modes. For example, a distant commander may require a high-level command interface and a "God's eye view" of a group of autonomous vehicles, while a remote operator requires a much more detailed interface to a single robot, including a high bandwidth teleoperation mode. The Interaction focus for this current BAA, however, addresses interaction with humans located in the robot's physical environment, including teammates, bystanders, and adversaries. For example, a human driver must interact with other human drivers, with pedestrians, and with other people, such as someone helping them back the vehicle into a tight space. Achieving equivalent robotic capabilities represents a potentially critical technology challenge for the deployment of autonomous vehicles in the real world. Exploratory efforts that will serve to establish the scope of effort required are especially encouraged.

- ***Path Referenced Perception and Behavior.*** Every movement of every vehicle (manned, teleoperated, or autonomous) represents an opportunity to gather information about the path it follows, and, if this is done effectively, that information can be used later by an autonomous vehicle to travel along that same path in either direction. The key is gathering, processing, and storing the information in a way that permits it to be used later. What is required is a perception-based representation of the path (the vehicle's actions and/or the characteristics of the environment) at as high a level of abstraction as can be achieved. Efforts in this area proposed under this current BAA should focus on path representations at various levels of abstraction.

- ***Environmental Perception.*** Efforts to develop perception capabilities for unmanned ground vehicles have traditionally focused on obstacle detection, terrain classification, and traversability assessment, while the canonical role for perception in weapons systems is in Automatic Target Recognition (ATR). Perception efforts proposed under this BAA should instead focus on sensing, interpreting, and "understanding" environmental features, including humans, e.g., model based approaches to perception of both static and moving objects.

PROGRAM SCOPE

Proposed efforts should cover a 24-month period of performance. The project schedule should include a kick-off meeting within a month of the award date, in-progress reviews at 6-month intervals, and multiple tests and evaluations during the final year. Up to $2.6 M may be available for the remaining FY2002 fiscal year.

Specific application/environmental domains will be concentrated on: outdoor on-road and off-road unmanned ground platforms; indoor mobile platforms; humanoids; and/or heterogeneous small ground and air platforms. Existing platforms will be heavily leveraged, both hardware (mobility base, sensor and communications suites) and software (robot architecture and basis

behaviors). DARPA anticipates selecting up to four application/environmental domains forming the demonstration thrusts for the MARS program.

Proposers may affiliate their proposals with other submitted proposals contributing to the program goals stated above under the umbrella of a selected application/environmental domain thus forming virtual collaborative research efforts. To facilitate the evaluators understanding of the collective proposed objectives, each affiliated proposal should include the same overall application/environmental domain description and a top-level group schedule in addition to their own technical research objectives, schedules, and costs.

Proposed research should investigate innovative approaches and techniques that lead to or enable revolutionary advances in the state-of-the-art. Proposals are not limited to the specific strategies listed above, and alternative visions will be considered. However, proposals should be for research that substantially contributes towards the goals stated. Research should result in prototype hardware and/or software demonstrating integrated concepts and approaches. Specifically excluded is research that primarily results in evolutionary improvement to the existing state of practice or focuses on a specific system or solution. Integrated solution sets embodying significant technological advances are strongly encouraged over narrowly defined research endeavors. Proposals may involve other research groups or industrial cooperation and cost sharing. This BAA shall remain open and proposals received up to one year following this BAA's release.

SUBMISSION PROCESS

The Defense Advanced Research Projects Agency/Information Technology Office (DARPA/ITO) requires completion of a **Broad Agency Announcement (BAA) Cover Sheet Submission** for each Proposal, by accessing the URL below:

http://www.dyncorp-is.com/BAA/index.asp?BAAid=02-15

After finalizing the **BAA Cover Sheet Submission**, the proposer must submit the **BAA Confirmation Sheet** that will automatically appear on the web page. Each proposer is responsible for printing the BAA Confirmation Sheet and submitting it attached to the "original" and each designated number of copies. The Confirmation Sheet should be the first page of your Proposal. Failure to comply with these submission procedures may result in the submission not being evaluated.

An original and **4** copies of the full proposal, and 2 electronic copies (i.e., 2 separate disks) of the full proposal (in Microsoft Word '97 for IBM-compatible, PDF, Postscript, or ASCII format on one 3.5-inch floppy disk or one 100 MB Iomega Zip disk). Each disk must be clearly labeled with BAA 02-15, proposer organization, proposal title (short title recommended) and Copy ___ of 2. The full proposal (original and designated number of hard and electronic copies) must be submitted in time to reach DARPA by 4:00 PM (ET) **Friday, May 17, 2002,** in order to be considered during the initial evaluation phase. However, BAA 02-15, MOBILE AUTONOMOUS ROBOT SOFTWARE (MARS)

ROBOTIC VISION 2020 will remain open until 4:00 PM (ET) **Thursday, April 3, 2003**. Thus, proposals may be submitted at any time from issuance of this BAA through **Thursday, April 3, 2003**. While the proposals submitted after **Friday, May 17, 2002,** deadline will be evaluated by the Government, proposers should keep in mind that the likelihood of funding such proposals is less than for those proposals submitted in connection with the initial evaluation and award schedule. DARPA will acknowledge receipt of submissions and assign control numbers that should be used in all further correspondence regarding proposals.

The typical proposal should express a consolidated effort in support of one or more technical topic areas. Disjointed efforts should not be included in a single proposal.

Restrictive notices notwithstanding: Proposals may be handled, for administrative purposes only, by a support contractor. This support contractor is prohibited from competition in DARPA technical research and is bound by appropriate non-disclosure requirements.

EVALUATION AND FUNDING PROCESSES

Proposals will not be evaluated against each other, since they are not submitted in accordance with a common work statement. DARPA's intent is to review proposals as soon as possible after they arrive; however, proposals may be reviewed periodically for administrative reasons. For evaluation purposes, a proposal is the document described in PROPOSAL FORMAT Section I and Section II (see below). Other supporting or background materials submitted with the proposal will be considered for the reviewer's convenience only and not considered as part of the proposal.

Evaluation of proposals will be accomplished through a scientific review of each proposal using the following criteria, which are listed in descending order of relative importance:

(1) Overall Scientific and Technical Merit: The overall scientific and technical merit must be clearly identifiable. The technical concept should be clearly defined and developed. Emphasis should be placed on the technical value of the development and experimentation approach.

(2) Innovative Technical Solution to the Problem: Proposed efforts should apply new or existing technology in a new way advantageous to the objectives. The plan on how the offeror intends to get developed technology and information to the user community should be considered.

(3) Potential Contribution and Relevance to DARPA Mission: The offeror must clearly address how the proposed effort will meet the goals of the undertaking. The relevance is further indicated by the offeror's understanding of the operating environment of the capability to be developed.

(4) Offeror's Capabilities and Related Experience: The qualifications, capabilities, and demonstrated achievements of the proposed principals and other key personnel for the primary and subcontractor organizations must be clearly shown.

(5) Plans and Capability to Accomplish Technology Transition: The offeror should provide a clear explanation of how the technologies to be developed will be transitioned to capabilities for military forces. Technology transition should be a major consideration in the design of experiments, particularly considering the potential for involving potential transition organizations in the experimentation process.

(6) Cost Realism: The overall estimated cost to accomplish the effort should be clearly shown as well as the substantiation of the costs for the technical complexity described. Evaluation will consider the value to Government of the research and the extent to which the proposed management plan will effectively allocate resources to achieve the capabilities proposed.

Proposals may be reviewed by non-government personnel; however, contractors will not be used to conduct evaluations or analyses of any aspect of a proposal submitted under this BAA, unless one of the three conditions identified in FAR 37.203(d) applies.

The Government reserves the right to select for award all, some, or none of the proposals received. Proposals identified for funding may result in a contract, grant, cooperative agreement, or other transaction depending upon the nature of the work proposed, the required degree of interaction between parties, and other factors. If warranted, portions of resulting awards may be segregated into pre-priced options.

GENERAL INFORMATION

Proposals not meeting the format described in this pamphlet may not be reviewed. Proposals **MUST NOT** be submitted by fax or e-mail; any so sent will be disregarded. This notice, in conjunction with this pamphlet, BAA 02-15 Proposer Information Pamphlet (PIP) and all references, constitutes the total BAA. No additional information is available, nor will a formal Request for Proposal (RFP) or other solicitation regarding this announcement be issued. Requests for same will be disregarded. All responsible sources capable of satisfying the Government's needs may submit a proposal that shall be considered by DARPA. Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs) are encouraged to submit proposals and join others in submitting proposals. However, no portion of this BAA will be set aside for HBCU and MI participation due to the impracticality of reserving discrete or severable areas of this research for exclusive competition among these entities.

NEW REQUIREMENTS/PROCEDURES: The Award Document for each proposal selected and funded will contain a mandatory requirement for submission of DARPA/ITO Quarterly Status Reports and an Annual Project Summary Report. These reports, described below, will be electronically submitted via the DARPA/ITO Technical – Financial Information Management System (T-FIMS), utilizing the government furnished Uniform Resource Locator (URL) on the World Wide Web (WWW).

(a) Status Report: Due at least three (3) times per year – Jan, Apr, & Oct

1) Technical Report
   a) Project General Information
   b) Technical Approach
      - Accomplishments
      - Goals
      - Significant changes / improvements
   c) Deliverables
   d) Transition Plan
   e) Publications
   f) Meetings and Presentations
   g) Project Plans
   h) Near term Objectives
2) Financial Report
3) Project Status / Schedule

(b) Project Summary (PSum): Due once each fiscal year in July
   1) All Sections of the Status Report
   2) QUAD Chart
      a) Visual Graphic
      b) Impact
      c) New Technical Ideas
      d) Schedule

PROPOSAL FORMAT

Proposals shall include the following sections, each starting on a new page (where a "page" is 8-1/2 by 11 inches with type not smaller than 12 point) and with text on one side only. The submission of other supporting materials along with the proposal is strongly discouraged. Sections I and II of the proposal shall not exceed 40 pages. Maximum page lengths for each section are shown in braces {} below.

Section I. Administrative

{1} Cover Page including: (1) BAA number; (2) Technical topic area; (3) Proposal title; (4) Technical point of contact including: name, telephone number, electronic mail address, fax (if available) and mailing address; (5) Administrative point of contact including: name, telephone number, electronic mail address, fax (if available) and mailing address; (6) Summary of the costs of the proposed research, including total base cost, estimates of base cost in each year of
the effort, estimates of itemized options in each year of the effort, and cost sharing if relevant; and (7) Contractor's type of business, selected from among the following categories: "WOMEN-OWNED LARGE BUSINESS," "OTHER LARGE BUSINESS," "SMALL DISADVANTAGED BUSINESS [*Identify ethnic group from among the following: Asian-Indian American, Asian-Pacific American, Black American, Hispanic American, Native American, or Other*]," "WOMEN-OWNED SMALL BUSINESS," "OTHER SMALL BUSINESS," "HBCU," "MI," "OTHER EDUCATIONAL," "OTHER NONPROFIT", or "FOREIGN CONCERN/ENTITY."

Section II. Detailed Proposal Information

This section provides the detailed discussion of the proposed work necessary to enable an in-depth review of the specific technical and managerial issues. Specific attention must be given to addressing both risk and payoff of the proposed work that make it desirable to DARPA.

[IMPORTANT NOTE: WITH THE EXCEPTION OF E, C THROUGH H HAVE BEEN REVISED.]

A. {1} Innovative claims for the proposed research. This page is the centerpiece of the proposal and should succinctly describe the unique proposed contribution.

B. {1} A "Proposal Roadmap" which shall address the following nine areas that must be addressed in the proposal. For each area, the roadmap will contain a summary statement (or "sound bite") for that area and identify the page number(s) where the issue is addressed in detail. It is important to make these statements as explicit and informative as possible.   The areas are:

   1. Main goal of the work (stated in terms of new, operational capabilities for assuring that critical information is available to key users).

   2. Tangible benefits to end users (i.e., benefits of the capabilities afforded if the proposed technology is successful).

   3. Critical technical barriers (i.e., technical limitations that have, in the past, prevented achieving the proposed results).

   4. Main elements of the proposed approach.

5. Specific basis for confidence that the proposed approach will overcome the technical barriers. ("We have a good team and good technology" is not a useful statement.)

6. Nature of expected results (unique/novel/critical capabilities to result from this effort, and form in which they will be defined).

7. The risk if the work is not done.

8. Criteria for evaluating progress and capabilities.

9. Cost of the proposed effort for each contract year.

C. {2}Research Objectives:

1. Problem Description. Provide concise description of problem area addressed by this research project.

2. Research Goals. Identify specific research goals of this project. Identify and quantify expected performance improvements from this research. Identify new capabilities enabled by this research. Identify and discuss salient features and capabilities of developmental hardware and software prototypes.

3. Expected Impact. Describe expected impact of the research project, if successful, to problem area.

D. Technical Approach:

1. {17}Detailed Description of Technical Approach. Provide detailed description of technical approach that will be used in this project to achieve research goals. Specifically identify and discuss innovative aspects of the technical approach.

2. {3}Comparison with Current Technology. Describe state-of-the-art approaches and the limitations within the context of the problem area addressed by this research.

E. {3} Statement of Work (SOW) written in plain English, outlining the scope of the effort and citing specific tasks to be performed and specific contractor requirements.

F. Schedule and Milestones:

1. {1}Schedule Graphic. Provide a graphic representation of project schedule including detail down to the individual effort level. This should include but not be limited to, a multi-phase development plan which demonstrates a clear understanding of the proposed research; and a plan for periodic and increasingly robust experiments over the project life that will show applicability to the overall program concept. Show all project milestones. Use absolute designations for all dates.

2. {3}Detailed Individual Effort Descriptions. Provide detailed task descriptions for each individual effort in schedule graphic.

G. {2}Deliverables Description. List and provide detailed description for each proposed deliverable. Include in this section all proprietary claims to results, prototypes, or systems supporting and/or necessary for the use of the research, results, and/or prototype. If there are no proprietary claims, this should be stated. The offeror must submit a separate list of all technical data or computer software that will be furnished to the Government with other than unlimited rights (see DFARS 227.) Specify receiving organization and expected delivery date for each deliverable.

H. {2}Technology Transition and Technology Transfer Targets and Plans. Discuss plans for technology transition and transfer. Identify specific military and commercial organizations for technology transition or transfer. Specify anticipated dates for transition or transfer.

I. {2} List of key personnel, concise summary of their qualifications, and discussion of proposer's previous accomplishments and work in this or closely related research areas. Indicate the level of effort to be expended by each person during each contract year and other (current and proposed) major sources of support for them and/or commitments of their efforts. DARPA expects all key personnel associated with a proposal to make substantial time commitment to the proposed activity.

J. {1} Description of the facilities that would be used for the proposed effort. If any portion of the research is predicated upon the use of Government Owned Resources of any type, the offeror shall specifically identify the property or other resource required, the date the property or resource is required, the duration of the requirement, the source from which the resource is required, if known, and the impact on the research if the resource cannot be provided. If no Government Furnished Property is required for conduct of the proposed research, the proposal shall so state.

K. {1} Experimentation and Integration Plans. Offerors shall describe how their results could be integrated with solutions that other contractors are currently developing or are likely to develop. In addition, offerors should identify experiments to test the hypotheses of their approaches and be willing to work with other contractors in order to develop joint experiments in a common tested environment. Offerors should expect to participate in teams and workshops to provide specific technical background information to DARPA, attend semi-annual Principal Investigator (PI) meetings, and participate in numerous other coordination meetings via teleconference or Video Teleconference (VTC). Funding to support these various group experimentation efforts should be included in technology project bids.

L. {5} Cost by task, with breakdown into accounting categories and equipment for the entire contract and for each contract year. Where the effort consists of multiple portions that could reasonably be partitioned for purposes of funding, these should be identified as contract options with separate cost estimates for each. Details of any cost sharing should

also be included.

MANDATORY! M. Contractors requiring the purchase of information technology (IT) resources as Government Furnished Property (GFP) **MUST** attach to the submitted proposals the following information:

   1. A letter on Corporate letterhead signed by a senior corporate official and addressed to **Dr. Douglas Gage,** DARPA/ITO, stating that you either can not or will not provide the information technology (IT) resources necessary to conduct the said research.

   2. An explanation of the method of competitive acquisition or a sole source justification, as appropriate, for each IT resource item.

   3. If the resource is leased, a lease purchase analysis clearly showing the reason for the lease decision.

   4. The cost for each IT resource item.

IMPORTANT NOTE: IF THE CONTRACTOR DOES NOT COMPLY WITH THE ABOVE STATED REQUIREMENTS, THE PROPOSAL WILL BE REJECTED.

Awards made under this BAA may be subject to the provisions of the Federal Acquisition Regulation (FAR) Subpart 9.5, Organizational Conflict of Interest. All affirmations must state which office(s) the offeror supports, and identify the prime contract number. Affirmations should be furnished at the time of proposal submission. All facts relevant to the existence or potential existence of organizational conflicts of interest, as that term is defined in FAR 9.501, must be disclosed in Section II, I. of the proposal, organized by task and year. This disclosure shall include a description of the action the Contractor has taken, or proposes to take, to avoid, neutralize, or mitigate such conflict.

Section III. Additional Information

A bibliography of relevant technical papers and research notes (published and unpublished) that document the technical ideas, upon which the proposal is based, may be included in the proposal submission.   Provide one set for the original full proposal and one set for each of the **4** full proposal hard copies. Please note: The materials described in this section, and submitted with the proposal will be considered for the reviewer's convenience only and not considered as part of the proposal for evaluation purposes.

The administrative addresses for this BAA are:

Fax: 703-522-7161 Addressed to: DARPA/ITO, BAA 02-15
Electronic Mail: baa02-15@darpa.mil
Electronic File Retrieval: http://www.darpa.mil/ito/Solicitations.html

Mail to: DARPA/ITO
        ATTN: BAA 02-15
        3701 N. Fairfax Drive
        Arlington, VA 22203-1714